THE PLANT DISEASE REPORTER

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RECENT STUDIES ON VIRUS DISEASES
OF APPLE IN THE UNITED STATES AND CANADA

Supplement 254 February 15, 1959

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THE PLANT DISEASE REPORTER

MYCOLOGY AND PLANT DISEASE REPORTING SECTION

Crops Protection Research Branch Plant Industry Station, Beltsville, Maryland

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OBSERVATIONS IN MAINE ON "STEM PITTING", A VIRUS DISEASE OF APPLE

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The stem pitting disease of apple has only recently been described. In 1954 Smith (6)[2] described the disorder in such body stocks as Virginia and Florence crabs growing in New Hampshire. Later Miller (3) in Nebraska and Tukey et al. (7) in Indiana noted a similar disorder in Virginia Crab. Tukey et al. (7), Smith (6), and Millikan and Guengerich (4) suggested that a virus may be involved. Early in 1956 Millikan and Guengerich (5) showed that the virus would cause leaves of Amelanchier to become dwarfed and rugose when diseased buds of Virginia Crab were inserted. Later that same year Guengerich and Millikan (1) were able to transmit the stem-pitting factor from diseased to healthy Virginia Crab trees by inserting diseased buds.

Hilborn and Hyland (2) demonstrated certain anatomical changes in stem-pitted wood and bark. Some of the cambial initials become multinucleate and the nuclei are distorted. The cambial derivatives become abnormal, resulting in the disorientation of xylem elements and phloem rays. Large "islands" of parenchymatous cells occur in the xylem, and the xylem rays may be multicelled. In the phloem the sieve tubes quickly degenerate and become nonfunctional, sieve areas and companion cells are lacking, and the phloem becomes completely disoriented.

From 1941 to 1951 various body stocks for apples were obtained through the courtesy of the Division of Plant Exploration and Introduction, Glenn Dale, Maryland. These were planted in an experimental orchard at Highmoor Farm in Monmouth, Maine, the experimental fruit farm of the Maine Agricultural Experiment Station. The planting was established in an attempt to find body stocks hardy enough to avoid the trunk and crotch type of winter injury that is so prevalent in Maine. As Virginia Crab trees were used as the standard for comparison in this planting there was an excellent opportunity to make preliminary studies on the host range of this virus within some apple varieties. The trees were examined during July and August, 1958, for the presence of stem pitting. The following information includes the observations and data taken during this survey.

Two V-shaped cuts were made in the bark of each tree examined, one at the soil line and one 3 feet above the soil line. The bark was then pulled downward and the sapwood examined for pitting. No attempt was made to evaluate the degree of pitting, a variety being recorded as pitted whenever any pitting was observed. This approach was made with the attitude that for this type of preliminary survey a positive reading would have more value than a negative reading. This means, of course, that some of the pitting noted may not have been caused by the virus, but may be due to other unknown factors.

Two general types of pitting were observed. In one the sapwood was uniformly pitted with short longitudinal depressions in the wood. The bark on such trees had corresponding extensions that fitted into the depressions in the wood. The bark was also very thick and brittle, and yellow in color. The second type of pitting exhibited a very fine, knitted pattern in slightly raised, narrow, grayish areas parallel to the stem. The bark was not so thick as with the first type, and it was not brittle and yellow.

Readings were also taken of the relative overgrowth of the top-worked scion variety at the union on the scaffold branches of the stock and the scion. A reading of 0 indicates that there was no overgrowth at this point and a smooth union existed. A reading of 2.5, for example, shows that considerable overgrowth occurred at the union.

Table 1 includes body stock varieties in which some form of pitting was found, Table 2 those in which no pitting was observed.

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[2]For references see page 7 in article following).

Table 1. Apple body stock varieties in which some form of pitting was found.

Body stock	No. trees examined	No. trees pitted	Scion variety top-worked on scaffold Branches	No. trees pitted: Soil Line	No. trees pitted: 3-foot level	Relative overgrowth of scion variety on: Pitted body stock	Relative overgrowth of scion variety on: Non-pitted body stock
Anis, 113472	4	1	Baldwin	1	0	3.0	1.8
Antonovka (Orono)[a]	5	1	Baldwin	1	0	3.0	1.1
Antonovka Shafron, 107197	4	1	Baldwin	1	0	1.0	1.0
Bedford	3	1	Baldwin	1	0	1.5	3
Belfer Foenicks, 107232	13	4	Baldwin	3	1	1.2	1.2
Belfer Kitaika, 90524	7	1	Baldwin	1	1	1.0	0
Bessemianka, 107202	5	1	Baldwin	1	0	0.5	0.25
Calros, 15153	7	2	Baldwin	1	1	3.0	2.5
	3	3	RedDelicious	3	2	3.0	
Charlamoff	9	1	Baldwin	1		3.5	2.0
Columbia, 123988	4	1	Baldwin	1	0	2.0	1.5
Dabinett, 150648	2	2	RedDelicious	2	2	1.7	
Dudley	4	3	Baldwin	3	2	3.1	2
Erickson, 148422	6	1	Baldwin	1	0	1.5	1.7
	4	2	RedDelicious	1	2	1.2	1.7
Flava, 107212	6	6	Baldwin	6	6	3.6	
Garnet	1	1	Baldwin	1	1	3	
Gros Frequin, 131105	4	1	RedDelicious	1	0	2	2.1
Harbin Selection, 161091	7	0	Baldwin	0	0		1.1
	7	1	RedDelicious	0	1	2	1.9
Hibernal	4	0	Baldwin	0	0		2.1
	2	0	Red Delicious	0	0		1.0
	4	1	Cortland	1	0	1.0	0.5
Krasnoznamennoie, 107227	5	2	Baldwin	1	1	1.5	2.0
Kulon Kitaika, 107229	4	2	Baldwin	2	0	0.5	0
	25	11	Cortland	4	8	1.4	.85
Kurosh's Renette, 136118	4	3	Baldwin	3	0	2.8	3
Lennoxville, 151643	4	0	Baldwin	0	0		1.1
	2	2	RedDelicious	1	2	1.5	
Malus wisantowoye, 104998	3	1	Baldwin	1	0	.5	1.5
M. mandshurica x White Astrachan, 154329	5	3	Baldwin	3	0	2.8	3.0
	4	2	RedDelicious	0	2	2.0	2.8

Table 1. (Continued)

Body stock	No. trees examined	No. trees pitted	Scion variety top-worked on scaffold branches	No. trees pitted: Soil line	No. trees pitted: 3-foot level	Relative overgrowth of scion variety on: Pitted body stock	Relative overgrowth of scion variety on: Non-pitted body stock
N. Queen x Cranberry Pippin, 141870	3	0	Baldwin	0	0	0	2
	3	3	Red Delicious	0	3	2.3	
Olga, 127702	5	5	Baldwin	5	5	4.0	
Osman, 123995	3	1	Baldwin	1	1	3	3.5
Pippin Shaffron, 104995	5	2	Baldwin	2	0	0	.3
Printosh, 144088	5	4	Baldwin	4	4	3.1	2.5
Robin, 144025	5	2	Baldwin	2	0	3	2.5
	4	3	Red Delicious	3	3	2.8	2.5
Rosilda, 123915	4	0	Baldwin	0	0		1.7
	2	1	Red Delicious	1	0		1.5
Rubinivoe, 107244	4	4	Baldwin	4	4	3.8	
Severn, 144030	8	7	Golden Del.	0	1	1.0	1.8
Sissipuk, 148500	4	4	Red Delicious	4	4	3.3	
Sugar Crab, 143974	7	7	Baldwin	7	7	3.5	
	3	3	Golden Del.	3	3	3.5	
Toschprince, 148487	5	4	Golden Del.	1	0	2.5	2.3
Virginia Crab	6	6	Baldwin	6	6	3.2	
	11	10	Red Delicious	10	9	1.75	2
	3	3	Golden Del.	3	3	2.0	
Wallace Hybrid, 143920	5	5	Baldwin	5	5	3.3	

[a]Propagated at Orono from an unknown bud source.

Table 2. Apple body stock varieties in which no pitting was found.

Body stock	No. trees examined	Scion variety top-worked on scaffold branches	Relative overgrowth of scion variety
Anaros, 139664	5	Baldwin	1.2
Antonovka Zheltaia, 107310	9	Baldwin	1.7
Arrow, 148703	4	Golden Delicious	2.7
Atlas, 143889	4	Baldwin	1.0
Beauty, 139665	3	Baldwin	2.0
Cestra Belfer Kitaika, 107204	4	Baldwin	0
Chinese Shampainen, 107206	4	Baldwin	2.0
Glen Dale, 171460	1	Baldwin	2
Izo Crab, 127696	4	Baldwin	.5
Mecca, 148480	7	Golden Delicious	0.85
McPrince, 113483	5	Baldwin	1.3
Redman, 148482	2	Baldwin	2
Toba, 151645	5	Golden Delicious	2.0
Tony, 148486	4	Baldwin	2.1
	3	Golden Delicious	1.5

SOME OBSERVATIONS ON THE EFFECT OF SCION ROOTING IN VIRGINIA CRAB INTERMEDIATE APPLE STOCK IN REGARD TO STEM PITTING

R. C. McCrum

Smith (6) reported that Virginia Crab and Florence Crab used as body stocks for apple varieties may not develop stem pitting when scion rooting occurs. The observations in Maine agree with this statement. Out of 88 Virginia Crab body stock trees in the hardy stock orchard at Highmoor Farm only eight were found to be free from stem pitting. All eight non-pitted trees were found to be scion rooted. This orchard contained trees top-worked to Baldwin and McIntosh but the eight trees free from pitting were top-worked to the Baldwin variety.

As a result of the preliminary survey in the fall of 1957 it was decided to examine at random a comparable number of pitted Virginia Crab bodystock trees for the presence of scion rooting. Two groups of pitted versus non-pitted trees in commercial apple orchards were also examined to determine whether scion rooting of the Virginia Crab body stock could be correlated with the stem-pitting factor.

Results of these observations carried out in the summer of 1958 are recorded in Tables 1 and 2.

Table 1. Scion roots on pitted Virginia Crab body stock

Scion variety top-worked on scaffold branches	Number trees examined	Number trees scion rooted	Number trees not scion rooted	Number trees with pitted scion roots
[a] McIntosh	4	4	0	4
[a] Baldwin	4	3	1	3
[b] Golden Delicious	5	3	2	3
[b] McIntosh	5	2	3	2

[a]Trees at Highmoor Farm
[b]Trees in commercial apple orchards

Table 2. Scion roots on non-pitted Virginia Crab body stock

Scion variety top-worked on scaffold branches	Number trees examined	Number trees scion rooted	Number trees not scion rooted	Number trees with pitted scion roots
[a] Baldwin	8	8	0	0
[b] Golden Delicious	5	5	0	0
[b] McIntosh	5	5	0	0

[a]Trees at Highmoor Farm
[b]Trees in commercial orchards

Table 1 shows that scion rooting did occur on the pitted Virginia Crab body stock. Scion roots on these pitted trees, however, were small and deeply pitted. All trees in this pitted group were poorly rooted and showed symptoms of decline. A few had only the small pitted scion roots for support, the seedling roots having been completely rotted away.

Table 2 indicates that all of the non-pitted Virginia Crab body stock trees in this study were scion rooted. Scion roots on these trees were free from pitting. These trees were far superior to the pitted scion rooted trees. They were larger in trunk diameter and had better root systems.

DISCUSSION

A preliminary survey has shown that some apple varieties being used as body stocks remain free of stem pitting under orchard conditions even though growing in close proximity to diseased trees in the same orchard. Stem pitting is not restricted to those varieties that are typically crab apple, but also occurs in some varieties whose ancestry shows only one-fourth

crab apple parentage. Other varieties that are typically crab apple have remained free to date of any symptoms of the virus.

These observations indicate that scion rooting in Virginia Crab body stock trees will not in itself suppress the stem-pitting factor. It does raise an interesting question in regard to scion rooting: that is, would the stem-pitting factor occur if the Virginia Crab were not top-worked until after scion rooting had been established? Studies of the growth rings in trees at the experimental farm at Highmoor show that the top-worked Virginia Crab trees began to exhibit anatomical symptoms of stem pitting about 1945. Most of these trees were planted in 1940 and the topworking was done in 1942-1944. Possibly in the trees examined in this study the pitted scion roots were formed after the anatomical changes occurred in the Virginia Crab stem. Thus scion roots produced afterwards could develop the same anatomical pattern. Longitudinal sections made through two pitted scion roots attached to their stems indicated that the roots originated in the same year that pitting occurred in the stem.

At the present stage of our knowledge it is impossible to distinguish cause from effect. The fact that the non-pitted trees were all scion rooted does not necessarily mean that the scion rooting prevented the pitting symptom from appearing. There is a possibility that a body stock tree affected with the pitting factor may not have the vigor to develop scion roots.

Experiments are now being carried out to determine whether scion rooting and time of topworking can be used to control stem pitting in Virginia Crab intermediate stock.

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MAINE AGRICULTURAL EXPERIMENT STATION, ORONO, MAINE
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THE OCCURRENCE OF STEM-PITTING AND DAPPLE APPLE VIRUS DISORDERS IN AN ORCHARD PROPAGATED WITH KNOWN SOURCES OF VARIETAL SCIONWOOD[1]

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Abstract

The occurrence and distribution of the stem pitting and dapple apple virus disorders were recorded in an orchard originally designed for a test of winter hardiness of apple body stocks. The stem pitting disorder occurred in the body stocks Virginia Crab, Florence Crab, and Red River Crab. The dapple apple disorder occurred in the varieties Cortland and McIntosh. Theories for the occurrence of both disorders in the same orchard and their association with the body stock Virginia Crab are proposed.

INTRODUCTION

In an effort to counteract injury and death to apple trees due to winter injury, a study was undertaken in an experimental orchard in Gilford, New Hampshire, to determine the desirability of using body stocks in the areas of the framework of the tree (trunk and major branch crotches) which are most susceptible to winter injury (5). The body stocks Virginia Crab and Florence Crab have been used as hardy interpieces (3) and were compared in this study with varietal trunks on seedling and Malling IV rootstocks. The apple varieties used were McIntosh (Rogers strain, and trees J-2 and B.F. 224), Northern Spy (B.F. 52), Red Spy (Farley strain), and Cortland (3).

MATERIALS AND METHODS

Trees for the experimental orchard were obtained or propagated in the following manner: The Rogers strain of McIntosh and the Farley strain of Red Spy were purchased from nurseries and were on seedling roots. The varieties McIntosh, Northern Spy, and Cortland were propagated on Malling IV and seedlings in the orchard nursery. Two trees, J-2 and B.F. 224, at the University of New Hampshire orchard were used as scionwood sources for the McIntosh variety. One tree, B.F. 52, was used as scionwood source for the Northern Spy, and one tree, also in the University orchard, was used as a scionwood source for the variety Cortland.

Virginia Crab and Florence Crab trees were purchased as 2-year-old stock and set in the orchard. These plants, once established, were whip-grafted on the scaffold limbs to the varieties McIntosh (J-2 and B.F. 224), Northern Spy (B.F. 52), and Cortland (from one tree).

The experimental part of the orchard was designed to include 10 rows with 30 trees in each row. Each of four groups of understocks was replicated 15 times within the 10 rows. There were six replicates per row. Nine of the 10 rows were designed so that two rows of each variety were adjacent to each other, and the single rows of each variety were not adjacent to a row of the same variety. The first row consisted of 10 trees of Cortland followed by 10 trees of McIntosh and 10 trees of Red Spy. The rootstocks of this row were planned with the regular series across the orchard. See Figure 1 for the experimental plan of the orchard.

The orchard was planted in 1941. During subsequent years some of the trees died and were replaced with other body stocks and rootstocks not in sequence with the original plan. However, the varieties were maintained. By 1957, 71 of the 300 original trees had been replaced.

The roughened bark surface of trees infected with the stem-pitting virus (2, 3) is not sufficient by itself to determine the presence of the disorder. In the experimental orchard all Virginia Crab and Florence Crab body stocks were examined by cutting through the bark and examining the surface of the xylem and inner phloem at the cambial area. Many seedling and Malling IV roots were examined in a similar manner, but no pitting was observed in these.

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[1] Published with the approval of the Director of the New Hampshire Agricultural Experiment Station as Scientific Contribution No. 234.

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Tree Number	Row D	E	F	G	H	I	J	K	L	M
7	4	V	4	V	4	4	V	4	V	4
8	C4	V	4	V	4	4	V	4	V	4
9	o4	V	4	V	4	4	V	4	V	4
10	r4	V	4	V	4	4	V	4	V	4
11	t4	V	4	V	4	4	V	4	V	4
12	lS	F	S	F	S	S	F	S	F	S
13	aS	F	S	F	S	S	F	S	F	S
14	nS	F	S	F	S	S	F	S	F	S
15	dS	F	S	F	S	S	F	S	F	S
16	S	F	S	F	S	S	F	S	F	S
17	MV	4	V	4	V	V	4	V	4	V
18	cV	4	V	4	V	V	4	V	4	V
19	IV	4	V	4	V	V	4	V	4	V
20	nV	4	V	4	V	V	4	V	4	V
21	tV	4	V	4	V	V	4	V	4	V
22	oF	S	F	S	F	F	S	F	S	F
23	sF	S	F	S	F	F	S	F	S	F
24	hF	S	F	S	F	F	S	F	S	F
25	F	S	F	S	F	F	S	F	S	F
26	F	S	F	S	F	F	S	F	S	F
27	V	V	4	V	4	4	V	4	V	4
28	RV	V	4	V	4	4	V	4	V	4
29	eV	V	4	V	4	4	V	4	V	4
30	dV	V	4	V	4	4	V	4	V	4
31	V	V	4	V	4	4	V	4	V	4
32	SF	F	S	F	S	S	F	S	F	S
33	pF	F	S	F	S	S	F	S	F	S
34	yF	F	S	F	S	S	F	S	F	S
35	F	F	S	F	S	S	F	S	F	S
36	F	F	S	F	S	S	F	S	F	S
	Mixed Row	Cortland	Spy	McIntosh	McIntosh	Cortland	Cortland	Spy	Spy	McIntosh

Legend

F = Florence Crab
S = Seedling (Malus sylvestris)
V = Virginia Crab
4 = Malling IV

FIGURE 1. Rootstock, interpiece and varietal plan of experimental orchard

Tree Number	Row D	E	F	G	H	I	J	K	L	M
7	CRA	CV	Y4	MVP	M4	C4	CVA	Y4	YV	M4
8	C4	CVP	Y7	MS	M4	C4	CV	YV	YV	M4
9	CR	CV	Y4	MVPA	M4	C4	CVA	Y7	YV	M4
10	CR	CVP	Y7	MVP	M4	C7	CV	Y4	YVP	M4
11	CR	CVA	Y4	MVP	M4	C4	CVA	Y4	YVP	M4
12	CDA	CF	YS	MF	MSA	CS	CF	YS	YF	MS
13	CS	CFPA	YS	M7	MSA	CS	CF	YS	YFP	MS
14	C7	CFP	YS	MF	MS	CS	CF	YS	Y7	MS
15	CS	CF	YS	MR	MS	CS	CF	YS	YF	MS
16	C7	CR	YS	MR	MS	CS	CF	YS	YF	MS
17	MVP	C4	YVP	M7	MVP	CVPA	C4	YVP	YR	MVP
18	MVP	CRA	YVP	M4	MVP	CV	C4	YVP	Y4	MVP
19	MVP	CRA	YVP	M4	MVP	CV	C4	YVP	Y4	MVP
20	MR	C4	YVP	M4	MVP	CVA	C7	YV	YR	MVP
21	MKA	C4	YV	M4	MVP	CVP	C4	YV	YR	MVP
22	MK	CS	YF	MS	M7	CFPA	CS	YF	YS	MDP
23	MK	CS	YF	MS	MR	CFPA	CS	YFP	YS	MK
24	MR	CS	Y7	MDP	MR	CF	CS	YR	YS	MF
25	MS	CS	YF	MS	MV	C7	CS	YK	YS	M7
26	MVP	CS	YF	MS	MK	CF	CS	YR	YS	MDP
27	YVP	CV	Y7	VM	M4	C4	CVP	Y7	YVP	M4
28	YV	CR	Y4	MV	M7	C4	CVP	Y7	YV	MDP
29	YV	CVPA	Y4	MV	MK	C4	CVP	Y4	YV	M7
30	YVP	CVPA	Y7	MV	MR	C4	CVPA	Y4	YVP	M4
31	YVP	CRA	Y4	MV	M4	C4	CVPA	Y4	Y7	M4
32	YR	CF	YS	MF	MS	CS	CR	YS	YF	MS
33	YFP	CF	YS	MS	MS	CS	CR	YS	YF	MS
34	YR	CF	YS	MFP	MS	CS	CR	YS	YF	MS
35	YS	CF	YS	MR	MS	CS	CR	YS	YF	MS
36	YS	CS	YS	MF	MS	CS	CF	YS	YF	MS

Legend

A = Dapple apple
C = Cortland
D = Red River Crab
F = Florence Crab
K = Malus sikkimensis
M = McIntosh
P = Malus stem-pitting
R = (Malus)robusta V
S = Seedling (Malus sylvestris)
V = Virginia Crab
Y = Northern or Red Spy
4 = Malling IV
7 = Malling VII

FIGURE 2. Experimental orchard indicating variety, interpiece or rootstock and disorder, 1957.

There were 69 trees with a body stock of Virginia Crab in the experimental block at the time of inspection. Fourty-four trees or 63.7 percent expressed symptoms of stem pitting. Thirty-nine trees remained of the original 75 trees with Florence Crab as an interpiece, and six or 15.3 percent of these showed symptoms of stem pitting. Four of the five Red River Crab replacement trees showed stem pitting symptoms. See Figure 2 for the occurrence of stem pitting.

Dapple apple (1, 4) was first noted about 1951, when a few boxes of fruit showing the symptoms were observed in the packing shed. During the following years tree records were kept as the fruit was picked, and the position of several trees that produced fruit with dapple apple symptoms was recorded. In 1954, when a general survey was made, 11 affected trees were located in the experimental block. All but two trees were on Virginia Crab body stocks; these two were replacement trees on Robusta V rootstock. The scionwood for these two trees is thought to have come from an infected tree. In addition, all affected trees were of the Cortland variety, except for three McIntosh trees which, it is suspected, may have had some Cortland scionwood grafted into them. In 1956 and 1957 additional surveys were made and 22 trees showing dapple apple symptoms on mature fruit were located in the experimental block. See Figure 2 for the occurrence of dapple apple infected trees.

DISCUSSION AND CONCLUSIONS

The experimental portion of the orchard was designed for a body stock study. The investigation of the virus disorders which appeared in the trees was incidental to the main purpose of the experiment but proved to be most interesting. Several features of the tree structure in the orchard made this study possible and suggested reasonable theories for disease occurrence.

The foremost feature was that all scionwood of each variety came from known sources of that variety. In the case of the variety Cortland all scionwood came from one tree. With this knowledge as basis the opportunity presented itself for tracing and understanding the sources of infection.

Stem pitting occurred in the Virginia Crab body stocks in all apple varieties regardless of the source of scionwood. That pitting did not occur in all the Virginia Crabs from any one source of apple variety scionwood indicates that the virus was not initially present in the scionwood. If not present in the varietal scionwood, then the virus must have been present in the Virginia Crab or in the seedlings upon which the body stock was originally propagated. More than 60 percent of the Virginia Crabs remaining in the experimental orchard were infected with the stem pitting disorder. It seems improbable that apple seedlings would be so highly infected with a single virus. There is no information concerning the seed transmissibility of this virus. The most reasonable conclusion is that the stem-pitting factor was present in body stocks when they were propagated. Since these body stocks were propagated in large quantities their source must necessarily be from many scionwood trees, some of which may be infected while others are not. The erratic distribution of the affected trees in the experimental orchard would tend to bear out this assumption. The stem-pitting virus (or viruses) is perpetuated with the infected scions during propagation of the body stocks.

The theory is proposed that the disorder dapple apple results from a compex of two viruses which, when coming together in one apple tree, cause the symptoms of dapple apple. Either virus alone within a single plant is latent. Dapple apple first occurred in Cortland trees which had Virginia Crab as their body stocks. It has not been observed to occur spontaneously on any other variety that is not suspected of having been grafted with infected material. The fact that it occurred originally and only on the Cortland variety, and only when the body stock was Virginia Crab, indicates an interaction of some sort between these two units. However, dapple apple does not occur on all Cortland-Virginia Crab combinations. Since we know that the Cortland scionwood was taken from one tree we can say with some assurance that the virus content for the Cortland variety is the same throughout the orchard. This, then, leaves the Virginia Crab as the variable factor. Some of the scionwood source trees used to propagate the Virginia Crab may contain one component, while the Cortland source tree contains the other component. When they are brought together in one tree, dapple apple symptoms are expressed. Seedlings can be eliminated as the perpetuating agent since the disorder has not been observed on other Cortland trees where seedlings have been used. The viruses causing the stem pitting and dapple apple disorders occur independently of each other.

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NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION
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PRELIMINARY EVALUATION OF SOME RUSSIAN APPLE VARIETIES AS INDICATORS FOR APPLE VIRUSES[1]

Gaylord I. Mink and J. R. Shay[2]

Summary

The Russian apple variety R12740-7A and several of its seedlings have been shown in preliminary tests to be of value for use as indicators of apple mosaic and stem-pitting viruses. A new disease called chlorotic leaf spot was induced in the Russian indicators used to index trees with known virus infection and varieties selected at random. Both chlorotic leaf spot and stem pitting symptoms developed on indicator trees used to index 27 of 36 trees representing 23 varieties. Further work is needed to determine the relationship between these two diseases.

The apple variety designated R12740-7A[3] was produced at the University of Illinois from seed received from Russia and has been used as a source of scab resistance in a cooperative apple breeding program. Selections from crosses of R12740-7A with various commercial apple varieties were distributed, along with other scab resistant items, to a number of cooperators in the United States and in Europe for field tests against prevailing strains of Venturia inaequalis (Cke.) Wint. One of the authors (Shay) examined an orchard at Elste, Holland in 1955 in which some 22 different scab resistant selections had been topworked into young trees showing symptoms of apple mosaic virus. Eight of these selections were seedlings of R12740-7A. All eight had either failed to grow following top-working or were growing abnormally. Apparently, these selections were sensitive either to the apple mosaic virus or to some other virus present in the stock trees. The leaves of affected shoots were unilaterally distorted and flecked with circular chlorotic spots not typical of apple mosaic variegation.

This paper reports the results of preliminary tests to evaluate R12740-7A and selected seedlings as indicator varieties for apple viruses.

MATERIALS AND METHODS

The variety R12740-7A and certain of its seedlings were used to index apple varieties known to be infected with a virus and varieties of unknown virus content. Isolates of apple mosaic and other viruses were collected from foreign apple varieties growing in experimental apple orchards of Purdue University at Lafayette, Indiana and from collections of Professors D. Cation of Michigan State University, H. H. Thornberry, University of Illinois, and D. F. Millikan, University of Missouri, and designated as follows:

Apple Mosaic Virus Sources:

ApM-1	From D. Cation. Received as scions of Snow variety and budded on seedling rootstocks.
ApM-2	do., except Red Astrachan variety.
ApM-3	From H. H. Thornberry. Reveived as scions of Hyslop (VC 52-3A) and budded on seedling rootstocks.
ApM-4	do., except Hyslop (VC 52-3B).
ApM-5	do., except Golden Delicious (VC 54-4).
ApM-6	Fraas Kalvill P. I. 104787.
ApM-7	Antonovka Funtovaja P. I. 231925.

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[1] Journal Paper No. 1353 of the Purdue University Agricultural Experiment Station, Lafayette, Indiana.

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ApM-8 Perzikrode Zommerapple. Received from Holland, 1956.
ApM-9 Ejbij. Received from Holland, 1956.

Stem-pitting Virus Sources:

SP-2 Severely pitted Virginia Crab sprout from the roots of severely pitted, own-rooted Virginia Crab tree at Purdue University Horticulture Farm.
SP-6 Red Delicious (HV 6-5) from D. Millikan showing stem pitting and fruit symptoms (Possibly scar skin).
SP-7 Red Delicious (SP 8-4) from D. Millikan showing stem pitting.

Apple varieties of unknown virus content were collected from various Indiana orchards as dormant scions in the spring of 1956. These were grafted on whole roots of seedlings purchased from the Milton Nursery, Milton, Oregon and planted in the nursery.

The indicator varieties used included R12740-7A and its seedlings and Virginia Crab. In 1956, only three seedlings of R12740-7A were available in sufficient numbers for testing. These were 27-69, 27-202, and 65-105. They had been propagated by budding on seedling rootstocks in 1952 and planted in the nursery.

The Virginia Crab clone used as an indicator variety was obtained from a 25-year-old tree growing at the Horticulture Farm, Purdue University, and designated K6. This tree, examined repeatedly since 1956, showed no evidence of pitting and trees propagated from it on seedling rootstocks have likewise remained free from pitting symptoms.

RESULTS

In the first experiment, buds from five virus sources (ApM-1, ApM-2, SP-2, SP-6, SP-7) were placed into 5-year old trees of the Russian seedlings 27-69, 27-202, and 65-105 in August 1956. One or two trees of each variety were inoculated with each virus source and two trees of each variety were left as unbudded controls. No symptoms were observed until May 1958, when leaf symptoms began to develop on inoculated trees. Final readings were taken in July, 1958, and the results are recorded in Table 1. Typical mosaic symptoms appeared in two of the three indicator varieties inoculated with the ApM-2 source. None of the varieties has as yet developed typical mosaic symptoms from the ApM-1 source. In all cases of inoculation with stem pitting sources the indicator varieties showed the stem pitting symptoms in one or both trees by July, 1958. In addition, stem pitting symptoms appeared in the trees of two of the indicator varieties inoculated with the ApM-2 source and one variety inoculated with the ApM-1 source.

A third disease syndrome was transmitted to one or more of the three indicator varieties from all virus sources. The symptoms were similar to those observed in the top-worked scions in the orchard in Elste, Holland. Young leaves developed pale yellow spots of varied sizes that persisted throughout the season. Affected leaves in most cases were small and moderately to severely distorted. The leaf spotting and distortion were less pronounced on leaves formed later in the season until finally the later summer leaves were largely symptomless. This syndrome was designed "chlorotic leaf spot" (CLS).

In a second experiment, carried out in the spring and summer of 1958, apple seedlings with a viable dormant bud that had been inserted the previous summer from one of three Russian varieties were used as indicator varieties. The seedlings were pruned to the inserted bud, potted in 6-inch pots and forced in the greenhouse in April. At budbreak a single bud from each of nine apple mosaic virus sources was inserted into the seedling stock below the indicator variety bud. Six trees of each indicator variety were used for each virus source and six trees remained uninoculated as controls. The trees were transplanted to the outdoor nursery in June and final readings of symptom development in the growing shoot of the indicator variety were made in July. The results are presented in Table 2. During the 4-month period, four of the apple mosaic virus sources had induced apple mosaic symptoms in one or more of the indicator varieties; five had induced stem pitting symptoms and all had induced chlorotic leaf spot symptoms. The uninoculated controls developed normally.

In the third trial, a random collection of apple varieties from several Purdue orchards and commercial orchards in Indiana were indexed on two of the Russian seedlings and on Virginia Crab K-6. As stated earlier, the K-6 clone of Virginia Crab has remained free from symptoms of stem pitting. First-year grafts of the varieties growing in the nursery row were

Table 1. Symptoms expressed by 5-year-old apple varieties of R12740-7A parentage, 2 years after bud-inoculation with known apple virus sources.

Virus Source	Symptoms expressed on stated Russian variety[a]		
	65-105	27-69	27-202
ApM-1	0	CLS,SP	CLS
ApM-2	M,SP	CLS,SP	M
SP-2	CLS,SP	CLS,SP	CLS,SP
SP-6	CLS,SP	-	CLS,SP
SP-7	-	CLS,SP	-
Control[b]	0	0	0

[a] - = not tested, 0 = no reaction, CLS = chlorotic leaf spot, SP = stem pitting, M = typical apple mosaic.
[b] No buds inserted in indicator trees.

Table 2. Symptoms expressed within 4 months on indicator trees after inoculation at budbreak with one of nine sources of apple mosaic virus.

Virus Source[a]	Symptoms expressed on Russian indicator variety[b]		
	R12740-7A	65-105	45-39
ApM-1	M,CLS,SP	CLS,SP	CLS,SP
ApM-2	CLS,SP	M,CLS,SP	CLS,SP
ApM-3	M	M,CLS	0
ApM-4	0	M,CLS	0
ApM-5	CLS	CLS	CLS,SP
ApM-6	0	0	CLS
ApM-7	CLS	CLS,SP	CLS
ApM-8	CLS	CLS,SP	SP
ApM-9	CLS	CLS	0
Control[c]	0	0	0

[a] See text for description and origin of virus source.
[b] 0 = no reaction, CLS = chlorotic leaf spot, SP = stem pitting, and M = typical apple mosaic.
[c] No buds inserted in indicator trees.

Table 3. Summary of results from indexing single trees of a number of apple varieties on Russian varieties 45-39 and 65-105 and on K-6 clone of Virginia Crab.

Variety Indexed in 1956 [a]	Orchard	Symptom development by July, 1958 on indicator varieties: Russian varieties [b] Chlorotic leaf spot	Russian varieties [b] Stem pitting	Virginia Crab K-6 [c] Stem pitting
Virginia Crab K-6	Purdue-Hort., 51	-	-	-
Antonovka Shafran	Purdue-O'Neal	-	-	-
Belle de Pontoise	" "	+	+	-
Blackjon	" Hort.	+	+	+
Cortland	Smith	+	+	-
Delicious	Purdue-Hort.	+	+	+
"	Smith	+	+	-
"	"	+	+	+
" ,Richared	Purdue-Hort.	+	+	-
" ,Starking	" "	+	+	-
Early Victoria	Purdue-O'Neal	-	-	-
Fredrick von Boden	" "	+	+	+
Gallia	Smith	+	+	+
Golden Delicious	Purdue-Hort. 51	+	+	+
" "	Purdue-Hort. 53B	+	-	+
" "	Smith	+	+	+
" "	Doud	+	+	-
Grimes	Purdue-Hort.	-	+	-
Hyslop	Hobbs	-	-	-
Jonathan	Smith	+	+	-
"	Doud	+	-	+
Lord Suffield	Purdue-O'Neal	+	+	-
McIntosh	Smith	+	+	-
Malling I	Doud	+	+	-
Malling II	"	+	+	-
Malling VII	"	+	+	-
"	"	+	+	-
"	"	+	+	+
Mantovana	Purdue-O'Neal	+	-	-
Rome	Purdue-Hort.	+	+	-
"	Doud	+	+	+
Staymen	Purdue-Hort.	-	-	+
Turley	Smith	+	+	-
Virginia Crab	Purdue-Hort. 51	+	+	+
" "	Purdue-Hort. 52	+	+	+
Winesap	Purdue-Hort.	-	+	-

[a] Indicator bud placed in two 1-year-old grafts of the variety to be indexed in August.

[b] The results obtained on the two Russian varieties 45-39 and 65-105 are grouped; if symptoms appear on one of the indicator trees used, a "+" is recorded in the column below.

[c] If stem pitting was found on one or both of the indicator trees used, a "+" is recorded in the column below.

budded in the scion portion with a bud of one of the indicator varieties in August, 1956. Two to four trees of each variety to be indexed were budded with one of each of the Russian seedlings 45-39 and 65-105 and with the K-6 clone of Virginia Crab. Examinations for leaf symptoms were made during the second year of growth of the indicator variety (1958) and for the stem pitting symptom in July, 1958. The results are summarized in Table 3. Thus far, only four varieties have failed to induce chlorotic leaf spot and/or stem pitting symptoms on one or more of the indicator trees. These are Antonovka Shafran, Early Victoria, Hyslop, and Virginia Crab K-6. Most of the varieties induced both chlorotic leaf symptoms and stem pitting symptoms on one of the Russian seedlings. A greater proportion of the varieties indexed positive for the stem-pitting virus on the Russian seedlings than on Virginia Crab K-6.

DISCUSSION

The Russian varieties used in these tests are worthy of further trials as sensitive indicators of the stem-pitting virus. In the experiment recorded in Table 2 the stem pitting symptoms appeared in the Russian indicators within 4 months after inoculation. In the indexing trial of 36 trees recorded in Table 3 the Russian seedlings expressed the stem pitting symptoms only in 15 cases. Further, the Russian seedlings are the only known indicators of the chlorotic leaf spot syndrome.

In the results recorded in Table 3 the chlorotic leaf spot and stem pitting symptoms are associated (either in presence or absence) in 32 of the 36 cases. The two syndromes were associated in indicator trees inoculated with buds of 27 of the 36 trees indexed. Experiments designed to elucidate the relationship between these two diseases are in progress.

PURDUE UNIVERSITY AGRICULTURAL EXPERIMENT STATION, LAFAYETTE, INDIANA
(Plant Disease Reporter, Supplement 254. 1959)

A SURVEY FOR STEM PITTING IN INDIANA APPLE VARIETIES[1]

Gaylord I. Mink and J. R. Shay[2]

Summary

A visual survey of commercial apple varieties revealed a range of 0 to 90 percent of trees showing stem pitting symptoms. Virginia Crab showed the most severe form of pitting of all varieties examined. A similar range in incidence of pitting was found in a visual survey of 6- to 8-year-old seedling trees. A limited survey of apple varieties for the stem-pitting virus by indexing on sensitive indicator hosts revealed that symptomless trees induced stem pitting symptoms in the indicator hosts in five of six cases. Therefore, a visual survey is not reliable as a sole means of determining the presence of the stem-pitting virus.

Stem pitting symptoms have been transmitted by grafting from pitted apple varieties to non-pitted Virginia Crab[3] and to other varieties[4]. It is of interest to know the extent of natural occurrence of the stem pitting symptoms on apple varieties and seedlings of bearing age. For this purpose, a general survey of varieties and seedlings was made in the Purdue University experimental orchards at Lafayette and Bedford, Indiana. The visual examination was supplemented by indexing in the cases of a few orchard trees.

MATERIALS AND METHODS

In the general survey, both commercial varieties and seedling trees were observed. The varieties consisted of bearing trees ranging from 10 to 35 years old. They were examined by making a V-shaped cut in the bark near the base of the tree. The bark was lifted and both xylem and phloem tissues examined. Preliminary examinations indicated that if pitting symptoms were mild they could be detected only at or near ground level. All trees on which data were collected were examined first at ground level. Trees on which no pitting symptoms were found were examined in two or more places. Pitted trees were classified into three classes of symptom severity: mild, moderate and severe.

The seedling trees were 6 to 8 years old and on their own roots. They had fruited and had been discarded from the apple breeding program. They were examined shortly after having been uprooted by a tractor. In these cases, the entire tree trunk was examined for stem pitting. All trees found to be pitted were classified into one of seven classes of symptom severity as follows:

Class 1 -- Shallow pits at or near ground level.
Class 2 -- Deep pits at or near ground level.
Class 3 -- Shallow pits in the trunk from ground level to a height of at least 3 feet. No pits on the lower limbs.
Class 4 -- Deep pits in the trunk from ground level to a height of at least 3 feet. No pits on the lower limbs.
Class 5 -- Combination of shallow and deep pits over the entire trunk and on basal portions of the lower limbs.
Class 6 -- Pitting generally more severe than Class 5.
Class 7 -- Compound pits present in large numbers on stems and twigs over the entire tree. Some pits visible on the stem and larger limbs without removal of the bark.

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[3] Guengerich, H. W., and D. F. Millikan. 1956. Transmission of the stem pitting factor in apple. Plant Disease Reptr. 40: 934-938.

[4] Mink, Gaylord I., and J. R. Shay. 1959. Preliminary evaluation of some Russian apple varieties as indicators for apple viruses. Plant Disease Reptr. Suppl. 254: 13-17.

A severity index for each cross was calculated as follows:

$$\frac{\text{(Number of trees in each class) x (Class value)}}{\text{Number trees classified}}$$

In the survey by indexing, individual trees were indexed for the stem-pitting virus by the use of three indicator varieties: 65-105, 45-39, and Virginia Crab K-6[4]. Buds from one of each of these indicators were inserted into the scion portion of two young grafts of each tree to be indexed. The indicator buds were inserted in August 1956, and final readings were taken on shoots from these buds in July 1958.

RESULTS

The results of a visual survey for incidence and severity of stem pitting symptoms in trees located on the Purdue experimental farms are presented in Tables 1, 2, and 3. Stem pitting symptoms were found in nine of the ten scion varieties examined (Table 1). The incidence ranged from none in Stayman Winesap to approximately 90 percent infection in the case of Delicious. With one exception, pitting in scion varieties was found to be mild and confined to relatively small portions of the tree. However, in the case of Virginia Crab, three trees out of 13 examined were found pitted over most of the above-ground portion of the trees. When Virginia Crab was used as an understock (Table 2) the incidence of pitting was found to be generally greater than when the variety was used as a scion. Seedling understocks did not appear to be so severely pitted as Virginia Crab understocks.

It was of interest to determine the occurrence of pitting symptoms on seedling trees that had never been united by graft with other varieties. Presence of virus in such trees must be attributed to an introduction by natural means. Data from a visual survey of nearly 900 6- to 8-year-old seedlings are presented in Table 3. There was a range from 16 percent to 90 percent of trees showing symptoms among the different crosses. There appear to be no differences in incidence or severity of stem pitting symptoms among crosses involving Malus atrosanguinea (Spaeth.) Schneid., M. floribunda Sieb., M. prunifolia (Willd) Barkh,, and M. pumila Mill. In progeny of the cross Starking x M. baccata jackii Rehd., however, only four trees of the 26 examined showed pitting symptoms. The most severe pitting was found on triploid seedlings resulting from crosses of diploid selections with tetraploid McIntosh.

Table 1. Incidence and severity of stem pitting symptoms in apple varieties of bearing age in Purdue University orchards at Lafayette and Bedford, Indiana, 1957 and 1958.

Variety	Number trees examined	Percent trees pitted	Classification of pitted trees[a]: Mild Percent	Moderate Percent	Severe Percent
Delicious	94	89	48	52	0
Turley	14	50	29	71	0
Starking Delicious	12	42	60	40	0
Virginia Crab	13	38	0	40	60
Gallia	32	34	73	27	0
Golden Delicious	63	33	71	29	0
Grimes	204	23	89	11	0
Winesap	22	23	100	0	0
Red Rome	9	22	0	100	0
Stayman Winesap	10	0	--	--	--

[a] Mild = Pits shallow and infrequent. Present only at ground level or near graft union.

Moderate = Both shallow and deep pits present in abundance near ground level or near graft unions.

Severe = Pits primarily deep and present in large numbers over the trunk and scaffold limbs.

Table 2. Incidence and severity of stem pitting symptoms in understocks of trees of bearing age in Purdue University orchards at Lafayette and Bedford, Indiana, 1957 and 1958.

Understock	Height grafted	Number trees examined	Percent trees pitted	Classification of pitted trees[a]		
				Mild Percent	Moderate Percent	Severe Percent
Virginia Crab	12-15"	47	98	2	9	89
Virginia Crab	Approx. 3'[b]	143	80	11	21	68
Seedling	10-12"	97	80	67	33	0
Clark Dwarf	[c]	43	74	23	54	23
Virginia Crab	10-12"	9	11	0	0	100

[a] Mild = Pits shallow and infrequent. Present only at ground level or near graft union.

Moderate = Both shallow and deep pits present in abundance near ground level or near graft union.

Severe = Pits primarily deep and present in large numbers over the trunk and scaffold limbs.

[b] The top variety was grafted on scaffold branches of Virginia Crab at points about 1 to 3 feet from the trunk.

[c] Consisted of a 4 inch interpiece between Virginia Crab rootstock and the scion variety.

Table 3. Incidence and severity of stem pitting in stems of 6- to 8-year-old apple seedlings, Lafayette, Indiana, 1957 and 1958.

Female parent	Male parent	Trees examined	Trees pitted	Severity index[a]
		No.	%	
McIntosh	Wolf River x 804[b]	35	71	1.4
Wolf River x 804	Jonathan	21	67	1.1
Jon x 26830-2[c]	Delicious	54	91	1.4
Macoun	Jon x 26830-2	10	50	1.4
McIntosh	Gol.Del. x 26829-2-2[c]	14	64	1.0
McIntosh	Jon x 26830-2	87	76	1.5
4N McIntosh	26829-2-2	64	83	3.3
McIntosh	19651[d] x 20 oz.	34	76	1.3
Starking	19651 x 20 oz.	14	71	1.6
McIntosh	Jon x R12740-7A[e]	17	76	1.0
McIntosh	R12740-7A x Del.	60	70	1.1
McIntosh	R12740-7A x 20 oz.	28	68	1.0
McIntosh	Wealthy x R12740-7A	96	53	1.1
4N McIntosh	R12740-7A	63	83	2.4
R12740-7A x Del.	Jonathan	38	69	1.0
R12740-7A x 20 oz.	Delicious	16	88	1.2
R12740-7A x 20 oz.	McIntosh	13	69	1.2
Wealthy x R12740-7A	Delicious	119	80	1.3
Geneva	Atlas	15	80	1.1
Geneva	Melba	14	93	1.1
Starking	Alexis	36	97	1.9
Starking	Malus baccata jackii Rehd.	26	16	1.0
Starking	Jonsib Crab	17	35	1.5

[a] See text for description of infection classes and formula for calculating severity index.

[b] Malus atrosanguinea (804)

[c] 26829-2-2 and 26830-2 are F_2 seedlings from a cross Rome Beauty x M. floribunda (821)

[d] M. prunifolia variety 19651

[e] M. pumila R12749-7A

Table 4. Transmission of stem pitting symptoms from pitted and non-pitted trees to three sensitive indicator varieties.

Variety[a] and rootstock of trees indexed 1956	Pitting in scion and rootstock portions of tree indexed	Symptoms on indicator varieties, July 1958[b]		
		65-105	45-39	K-6
Virginia Crab K-6/unkn	None/none	0	0	0
Virginia Crab/unkn	None/none	0	+	+
Golden Delicious/unkn	None/none	0	+	+
Rome/unkn	None/none	0	0	+
Richared Delicious/Va.Crab	None/none	+	+	0
Starking Delicious/Va.Crab	None/none	+	+	0
Virginia Crab on own roots	Severe	+	+	+
Blackjon/Va. Crab	None/severe	+	+	+

[a] Buds for indexing were collected from the scion portion of each.
[b] 65-105 and 45-39 are seedlings of the Russian variety 12740-7A. Virginia Crab K-6 was observed for 3 years and found to be free from stem pitting symptoms.

Unfortunately, there was an insufficient number of indicator trees available to index the seedling trees examined for the stem pitting symptoms. Consequently, it is not known whether the large number of symptom-bearing trees would actually have transmitted the stem-pitting virus. However, there were enough trees available of three indicator varieties to index a limited number of apple varieties. These results are presented in Table 4. Five trees that did not display stem pitting symptoms in routine examinations induced stem pitting symptoms on one or two of the three indicator hosts. These data suggest that visual examination of trees for pitting symptoms is not reliable as a sole means of selecting clones free from the stem-pitting virus.

PURDUE UNIVERSITY AGRICULTURAL EXPERIMENT STATION, LAFAYETTE, INDIANA
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VIRUS STEM PITTING OF APPLE BODY STOCKS IN BRITISH COLUMBIA

F. W. L. Keane[2] and Maurice F. Welsh[3]

Abstract

Trees of 27 apple and crabapple varieties that are in use or under test as body stocks in British Columbia have been examined for stem pitting symptoms. Symptoms have been found in body stocks of Beauty Crab, Columbia Crab, Hyslop Crab, Malus robusta No. 5, Robin Crab and Virginia Crab. Stem pitting has been found also in top-worked limbs of Golden Delicious.

INTRODUCTION

The stem pitting disease has seriously impaired the performance of Virginia Crab as a body stock in British Columbia as in other areas (1, 3, 4, 5). All available information on the effect of this disease on other hardy varieties used as body stocks is of value. Surveys in plantings of a number of these varieties in British Columbia have provided an opportunity to obtain such information.

The testing of hardy varieties as apple tree body stocks was initiated by Mr. A. J. Mann of the Summerland Experimental Farm in the years 1938-41 (2). Promising hardy varieties were propagated on seedling and clonal rootstocks, and supplied to orchardists in areas with histories of cold injury. After 2 to 3 years the trees were top-worked with scionwood some of which was supplied from the Experimental Farm by Mr. Mann. The scion variety was budded or grafted on framework branches 18 inches or more from the trunk. Several additional blocks of Virginia Crab and Hibernal were set out by nurserymen or orchardists in 1941 and 1942, and these were top-worked with commercial varieties by the owners. Many plantings remain, and are fully mapped, providing excellent opportunities for the recording of stem pitting occurrence.

PROCEDURE

In 1955, following a discussion of stem pitting with Mr. H. W. Guengerich, surveys for the disease were initiated in all surviving plantings of trees on hardy body stocks. Most of the survey was completed in 1955. Several additional plantings were surveyed in 1957 and 1958. All trees were 16 to 19 years old when surveyed, except those with Malus robusta No. 5 frameworks which were 6 to 7 years old.

Following preliminary surveys of Virginia Crab plantings, the characteristics of frameworks affected by stem pitting were established. The most reliable symptom is the presence of pits in sapwood matched by projections from the inner surface of the bark. These pits may be isolated and shallow. In severely affected frameworks they may develop into densely arranged deep longitudinal grooves. Gross tree characteristics associated with stem pitting include dwarfing; a low-spreading and open-centre growth habit; reduced diameter of trunk and limbs; longitudinal depressions in the trunk, sometimes extending into the limbs; overgrowth of the top-worked variety at the unions; reduced production of watersprouts from the affected body stock, and abundant production of suckers from the rootstock below.

In earlier phases of the survey stem pitting was assessed by raising inverted V-shaped flaps of bark in the scaffold branches, and at the base of the trunk within 12 inches of ground level. As the survey progressed, modifications were made in this procedure. "V" cuts were made at the base of the trunk of all body stock varieties for which limited numbers of trees were available. In large blocks of trees for which all body stocks were of a single variety,

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Table 1. Body stock varieties inspected for occurrence of stem pitting.

Framework variety	Number of plantings inspected	Number of trees inspected	Number of trees pitted
Anis	1	1	0
Antonovka	4	20	0
Atlas	2	9	0
Beauty Crab	1	3	3
Bedford Crab	2	6	0
Canada Baldwin	3	15	0
Charlamoff	6	111	0
Columbia Crab	1	2	1
Dolgo Crab	2	8	0
Florence Crab	1	5	0
Haas	1	4	0
Haralson	5	179	0[a]
Hibernal	11	975	0[a]
Hyslop Crab	2	12	5
Lobo	1	13	0
Malus baccata	3	11	0[a]
Malus robusta No.5	4	45	11
Melba	2	9	0
McIntosh	2	10	0
Olga Crab	2	10	0
Osman Crab	4	23	0
Pioneer Crab	1	1	0
Robin Crab	1	5	5
Tony Crab	3	10	0
Transcendent Crab	1	4	0
Virginia Crab	11	1,534	1,310
Winter St. Lawrence	2	3	0

[a] One or more trees with trace of atypical stem pitting.

especially Charlamoff and Hibernal, that had proved consistently free from stem pitting, the bark cuts were made only in a sampling of trees that included all those with gross tree characteristics that rendered them subject to suspicion. Also, in large blocks of Virginia Crab the trees that displayed severe gross symptoms were recorded as diseased without recourse to bark cuts.

RESULTS

The number of trees of each variety examined, the number of plantings in which observations of each were made, and the number of trees of each body stock variety in which pitting was found, are listed in Table 1.

Bark cutting was practised on a sampling of commercial varieties growing on various body stocks. Stem pitting was found in three Golden Delicious top-worked on Haralson, three Golden Delicious top-worked on Malus robusta No. 5, and three Golden Delicious top-worked on pitted Virginia Crab. No typical stem pitting was found on other commercial varieties, in occasional examinations that were made in main limbs, as close as possible to their junctions with affected Virginia Crab frameworks.

Traces of possible pitting were found in three Haralson body stocks, one Hibernal body stock, and one Malus baccata body stock. The pitting was not considered sufficiently severe or characteristic to be listed as a positive reading.

DISCUSSION

These surveys obviously give only an indication of the reactions of the various body stock varieties to stem pitting. Varieties such as Charlamoff, Haralson, and Hibernal for which large numbers of trees showed no symptoms, are undoubtedly unaffected, or affected so mildly that effects are not evident. This conclusion is fortified when such body stocks are interplanted with pitted Virginia Crab and have been top-worked with the clones of commercial varieties that are top-worked on the pitted Virginia Crab body stocks also.

In those body stock varieties for which small numbers of trees in a limited number of plantings were available for observation, there remains considerable doubt whether negative survey results are significant.

Throughout this survey rather rigid specifications were required for the recording of positive readings of stem pitting. Two types of pitting were found that were deemed atypical: one a "reverse pitting", with pegs of wood extending into the bark; the other a fine continuous longitudinal grooving in the wood, with corresponding fine continuous ridges on the inner surface of the bark. Both types of symptoms were found in varieties top-worked on both pitted and non-pitted Virginia Crab frameworks, and were therefore considered unassociated with presence of stem-pitting virus.

For all body stock varieties that are at present recommended for British Columbia, or that show sufficient promise to suggest possible future recommendations, transmission tests with the stem-pitting virus are in progress.

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BOTANY AND PLANT PATHOLOGY DIVISION, SCIENCE SERVICE, CANADA DEPARTMENT OF AGRICULTURE
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PRELIMINARY RESULTS IN THE INDEXING OF APPLE IN BRITISH COLUMBIA

Maurice F. Welsh[2] and F. W. L. Keane[3]

Abstract

Representative trees of commercial and body stock varieties grown in British Columbia are being indexed for virus infection. Positive results in 1958 suggest that the viruses of rubbery wood and of stem pitting are distinct, and show that each of these viruses is being carried in trees of several varieties. An apparently unrecorded virus transmitted from Rome Beauty causes stunting and decline of Virginia Crab. Foliage symptoms have appeared in Prunus tomentosa seedlings following inoculations from Virginia Crab trees with and without stem pitting. Attempted inoculations with the stem-pitting virus have not yielded symptoms in West Indian lime seedlings.

INTRODUCTION

Within the last several years there has appeared strong need to assess the prevalence and importance of viruses in British Columbia apple plantings. The only apple virus demonstrated in British Columbia Interior plantings before 1956 was that of apple mosaic, found in a single Delicious tree and transmitted to one tree each of Delicious and McIntosh (2). In 1957 the virus nature of the leaf pucker disease in McIntosh and Spartan was reported (6). No information has been available on the extent to which other viruses are carried in the trees of commercial orchards or in scion source trees at the Experimental Farm.

Accordingly, in 1956, materials were assembled for the initiation of an indexing program. The immediate objectives were, first, to assess the prevalence in commercial varieties of the viruses responsible for stem pitting and rubbery wood, by sampling various clones of these varieties; and, secondly to determine the effects of these viruses on the commercial and body stock varieties commonly grown in British Columbia orchards or currently recommended for planting.

MATERIALS AND METHODS

Lord Lambourne apple was used as the standard indicator host for rubbery wood, and Virginia Crab for stem pitting. Limited trials were made of two other plants as indicator hosts for stem pitting. One of these was Prunus tomentosa, reported by Millikan and Guengerich (3) as a host that develops foliage symptoms when inoculated with pitted Virginia Crab. Tests were also made of the suitability of West Indies lime seedlings as indicators. The use of these was suggested by their ability to develop stem pitting symptoms when inoculated with the tristeza virus (5).

All test apple trees used in the indexing experiments were grown on Malling II rootstocks propagated by the East Malling Research Station from stools indexed for freedom from viruses recognized in England. Healthy Virginia Crab materials propagated on these stocks have been consistently symptom-free, indicating that the clone is free from stem-pitting virus also. The clone of Lord Lambourne used for indexing of rubbery wood was obtained from the East Malling Research Station, where it had been indexed for freedom from virus. The source of Virginia Crab for all test trees used in the indexing of stem pitting was a symptom-free tree E. F. 9J-P30 on the Summerland Experimental Farm.

Test apple trees were created by the simultaneous summer budding of Malling II rootstocks with two inoculum buds that were applied at the base of the trunk, and with two buds of the

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indicator variety applied to the trunk immediately above. Growth of the upper buds was forced. Only cambial union was demanded for the inoculum buds, although many of them originated growing shoots. All inoculations were made into paired trees, with a single uninoculated tree serving as a check.

Rubbery wood readings were made in midsummer by the hand bending method (4) and by observation of the growth habit of test trees (Fig. 1). Stem pitting readings were made by lifting large flaps on the trunks, immediately above the union of indicator and rootstock, and by stripping bark of lateral branches of test trees.

FIGURE 1. Rubbery wood in Lord Lambourne. Apple tree at right received buds from Delicious E.F. 9D-90910. Tree in centre is uninoculated check.

Prunus tomentosa seedlings were grown in 1-gallon cans in the greenhouse, inoculated by summer budding when approximately 2 feet high, and headed back immediately to a height of 12 to 15 inches, to force new growth. Ten test trees received buds from a pitted Virginia Crab tree (Splett 1); four received buds from a non-pitted Virginia Crab tree (Hait BB-22); and four received buds from the non-pitted source tree E.F. 9J-P30. Symptom readings were made at intervals during 8 months after inoculation.

West Indian lime seedlings were grown in cans in the greenhouse, from seeds supplied by Dr. J. M. Wallace. They were treated in July, when they were approximately 10 inches high. The methods attempted for their inoculation were: (a) the insertion, beneath the bark through T-shaped cuts, of cambium pieces from apple source trees; (b) the rubbing of young lime leaves with the inner surface of freshly removed apple bark; (c) leaf grafting, by inserting apple leaves into clefts made at leaf axils of the lime seedlings, a slight adaptation of the method described by Bringhurst and Voth (1); and (d) approach grafting from apple shoots held in beakers of water. The three Virginia Crab trees used as sources for Prunus tomentosa tests were used in the attempts to inoculate lime seedlings. Observations were made at intervals during a period of 11 months.

RESULTS AND CONCLUSIONS

All positive results are recorded in Table 1. Negative results have been omitted, because additional positive results on Lord Lambourne and Virginia Crab are expected in ensuing years. This expectation is supported by a small proportion of negative readings in 1958 for perpetuation of both stem pitting and rubbery wood, and in various tests that involved transmission of the viruses of these diseases from known infected sources. All recorded results were given by both trees of the inoculated pair. The check tree for each test gave a negative reading for the virus concerned in that test.

Table 1. Virus indexing of apple varieties; positive results obtained in 1958.

Source Tree	Stem Pitting	Rubbery wood	Virginia Crab decline	Prunus tomentosa leaf mottle
Tree 1 (E.F. 9D-90910, Delicious)	x	x		
Tree 2 (Hait U-7, Delicious on pitted Virginia Crab)	x			
Tree 3 (Hait GG-13, Delicious on non-pitted Virginia Crab)		x		
Tree 4 (9D-91912, Winesap on pitted Virginia Crab)	x	trace		
Tree 5 [a] (Hait V-12, Spartan on pitted Virginia Crab)	x			
Tree 6 (Skelly H-20, Golden Delicious on pitted Virginia Crab)	x			
Tree 7 (Evans 1, Golden Delicious)	x			
Tree 8 (E.F. 3-17-1, Rome Beauty)	x	trace	x	
Tree 9 (Hait BB-22, non-pitted Virginia Crab)				x
Tree 10 (Splett 1, pitted Virginia Crab)				x

[a] The Spartan and the Virginia Crab portions of this tree were applied separately to indicator trees. Results were the same.

Significant information provided by the 1958 results of indexing is as follows:

1. Rubbery wood virus has been demonstrated present in two 16-year-old indexed Delicious trees, neither of which displays any obvious abnormalities. Tree 1 is known to be a Turner Red Delicious. Tree 3 is a red strain of Delicious, believed to be Turner Red. One Seeando Winesap tree and one Rome Beauty tree, apparently normal in growth habit, have indexed as strongly suspicious for rubbery wood. These are the first demonstrations of the occurrence of rubbery-wood virus in British Columbia apple plantings.
2. The stem-pitting virus has been demonstrated present in Delicious, Spartan, and Winesap clones growing on pitted Virginia Crab body stocks; and in Delicious, Golden Delicious, and Rome Beauty clones that have had no known contact with Virginia Crab. This substantiates considerable circumstantial evidence for the common occurrence of the virus in clones of commercial apple varieties.
3. The rubbery-wood virus has been demonstrated present in one tree that also carries stem pitting, and is strongly suspected in two additional trees that carry stem pitting. However, rubbery-wood virus has been demonstrated to be present also in one clone of Delicious growing on Virginia Crab body stock that shows no suspicion of stem pitting, and that has not perpetuated or transmitted stem pitting in three separate tests. These results provide limited but strong evidence that the viruses of rubbery wood and stem pitting are distinct.
4. None of the young Lord Lambourne indicator trees, whether inoculated from stem pitting sources or not, showed typical pitting symptoms in 1958. However, almost all Lord Lambourne trees showed a "reverse pitting" with pegs of wood tissue penetrating into the inner tissues of the bark. The significance of this symptom is difficult to assess.
5. A tree of Rome Beauty in Experimental Farm plantings, showing no gross symptoms, has not only indexed positive for stem pitting, and strongly suspicious for rubbery wood, but has caused a striking dwarfing and decline of Virginia Crab. This decline (Fig. 2) appears to be far more severe than the usual effect of the stem-pitting virus. By mid-Aug-

FIGURE 2. Dwarfing and decline of Virginia Crab. Tree at left received buds from Rome Beauty E.F. 3-17-1. Tree at right is uninoculated check.

ust of the year following inoculation, the trunk diameters of inoculated trees were approximately one-half the diameter of the check tree. Inoculated trees had a weeping growth habit. Their foliage was pale green, with about one-quarter of the leaves turning yellow from the margin, and dropping. The fruits were about one-half normal size and ripened prematurely, with flesh water-soaked from the core outwards. There appears justification for ascribing this decline to a virus distinct from those causing stem pitting and rubbery wood.

6. In Prunus tomentosa, foliage mottling resembling that described by Millikan and Guengerich (3) has been induced. The symptoms developed in six trees that received buds from the pitted Virginia Crab tree Splett 1, two of those that received buds from non-pitted Virginia Crab tree BB-22, and none of those that received buds from non-pitted Virginia Crab tree E.F. 9J-P30. Thus the P. tomentosa symptoms have followed inoculation from pitted and from apparently non-pitted Virginia Crab. Tree Hait BB-22 which is 16 years old, has shown no evidence of stem pitting after very careful examination. The results therefore suggest that the symptoms in P. tomentosa are caused by a virus distinct from that of stem pitting.
7. Attempts to inoculate a total of 44 lime seedlings by the four described techniques, 28 of these with material from a pitted Virginia Crab tree, and eight with material from each of two non-pitted trees, have induced neither foliage nor stem pitting symptoms in the test seedlings. Six leaf inserts remained green for 3 weeks or more, and a small proportion of the approach grafts and cambial insertions made definite union. Therefore the opportunity for virus transmission was provided, and evidence was yielded that the virus of apple stem pitting does not cause stem pitting in lime seedlings.

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BOTANY AND PLANT PATHOLOGY DIVISION, SCIENCE SERVICE, CANADA DEPARTMENT OF AGRICULTURE
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REACTION OF OWN-ROOTED TREES OF SPY 227 AND VIRGINIA CRAB TO INFECTION WITH THE STEM-PITTING VIRUS[1]

H. W. Guengerich and D. F. Millikan

Abstract

The apple rootstock clone, Spy 227, appears to be a good indicator for apple viruses. Inoculation with an isolate of the stem-pitting virus caused severe stem pitting of Spy 227. Own-rooted Spy 227 trees were killed by the same isolate. This suggests that the previously reported lethal rootstock-scion combinations may have been due to infection with the stem-pitting virus.

INTRODUCTION

In 1948, Weeks (4) published the third of a series of papers concerning the uncongeniality associated with combination between scion varieties and the USDA rootstock, Spy 227. The possibility that a virus infection was associated with the lethal action was considered in this report and evidence was presented showing that this uncongeniality of one clone could be transferred to a non-lethal clone. Previous tests (2) showed that Spy 227 on seedling roots developed pitting on the wood following inoculation with buds from scion sources known to contain the stem-pitting virus. These reports, and an earlier one by Tukey and Brase (3) concerning the uncongeniality of McIntosh on Virginia Crab prompted the authors to compare Spy 227 with Virginia Crab as an indicator.

EXPERIMENTAL METHODS AND RESULTS

Spy 227 scionwood was received in August 1954, from C. P. Harley of the United States Department of Agriculture. The clone was increased by budding into domestic seedlings. In 1956, softwood cuttings of a single Spy 227 tree were rooted under intermittent mist. Virginia Crab from a single tree known to be free from infection with the stem-pitting virus was increased by both softwood cuttings and bench-grafting to domestic seedlings. These were lined out in the spring of 1957 and inoculated the subsequent August.

Two sources of inoculum were used in the study. One, GD-A, was a single tree increase from a parent Golden Delicious tree showing no pitting on the Virginia Crab stem. The other source, GD-C, was a bearing tree showing a severely cracked and pitted Virginia Crab stem. One half of the test plants were inoculated with the infected source, GD-C, and the other half were budded with clone GD-A. In April 1958 one half of the trees inoculated from a diseased source were cut back so that the inoculum tissue dominated. Trees budded from the disease-free source were treated in a similar fashion and observations were made beginning in July and terminating in September. These data are listed in Table 1.

DISCUSSION

From the date listed in Table 1, it appears that the cause for the uncongeniality of apple lethal to Spy 227 could be the stem-pitting virus. The observation that Spy 227 trees cut back to the inoculating bud and forced are longer lived than Spy 227 not cut back is in agreement with Gardner, Marth and Magness' (1) observation of Rome Beauty worked on Spy 227. Most of the roots on the two surviving trees of the virus-inoculated and forced group were found to be dead at the last inspection. This also agrees with observations of Gardner, Marth and Magness (1).

Own-rooted Virginia Crab and the same clones on seedling roots behaved similarly to trees infected with the stem-pitting virus. However, the pitting on own-rooted trees seemed to be somewhat less severe than that on trees with seedling roots.

[1] Journal Series Paper No. 1924, approved by the Director of the Missouri Agricultural Experiment Station.

Table 1. Effect of virus infection upon Spy 227 and Virginia Crab clones of apple.

Scion	Rootstock	Inoculum	Number of trees: Cut back to bud and forced	Number of trees: Not cut back	Reaction: Date of observation	Reaction: Type
Spy 227	Spy 277	GD-A	3		9/8/58	All alive
Spy 227	Spy 227	GD-A		3	9/8/58	All alive
Spy 227	Spy 227	GD-C	5		7/1/58	1 dead
					8/30/58	2 dead
Spy 227	Spy 227	GD-C		5	9/8/58	3 dead
						2 alive
Spy 227	Spy 227	GD-C		5	7/1/58	1 dead
					8/13/58	2 dead
					9/8/58	5 dead
Va. Crab	Seedling	GD-A	4		9/8/58	None pitted
Va. Crab	Seedling	GD-A		4	9/8/58	None pitted
Va. Crab	Seedling	GD-C	5		9/8/58	All pitted
Va. Crab	Seedling	GD-C		5	9/8/58	All pitted
Va. Crab	Va. Crab	GD-A	2		9/6/58	None pitted
Va. Crab	Va. Crab	GD-A		3	9/6/58	None pitted
Va. Crab	Va. Crab	GD-C	5		9/6/58	All pitted
Va. Crab	Va. Crab	GD-C		5	9/6/58	All pitted

SUMMARY

When inoculated with an isolate of the stem-pitting virus the apple rootstock Spy 227 gives a reaction similar to that observed when certain clones of apple are budded to it. The lethal effect of the virus is delayed if the clone is cut back to the inoculated bud and forced. This suggests that the factor responsible for lethal uncongeniality in apple may be the stem-pitting virus, and indicates that Spy 227 may be a good indicator for pome fruit virus studies.

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MISSOURI AGRICULTURAL EXPERIMENT STATION
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SOME POMACEOUS INDICATOR HOSTS FOR THE STEM-PITTING VIRUS OF APPLE

D. F. Millikan and H. W. Guengerich[1]

Abstract

Host range studies involving several pomaceous species revealed indicator hosts for the stem-pitting virus in clones of Malus floribunda, M. platycarpa (B-39478), Crataegus crus-galli, C. mollis, and Amelanchier spp. Clones of M. floribunda and M. platycarpa appear to be particularly promising as indicator hosts.

INTRODUCTION

The widespread occurrence of stem-pitting virus in our commercial clones and varieties has stimulated a search for an indicator superior to Virginia Crab. Virginia Crab when used as indicator plant requires an incubation period approaching 12 months. In addition, the stripping of the bark necessary to observe the pitting characteristic of infection is laborious and destroys the tree. Consequently several genera and species closely related to apple were collected and inoculated with an isolate of the stem-pitting virus. These host plants were then evaluated on the basis of severity of symptoms.

EXPERIMENTAL METHODS AND RESULTS

During the first 2 years seedlings of Amelanchier spp., Aronia spp., Cotoneaster spp., Crataegus crus-galli, C. mollis, Malus floribunda, Photinia spp., Sorbus americana, and S. aucuparia were screened by inoculating with the virus and observing the development of symptoms over a 2-year period. Most of these seedlings offered no improvement over Virginia Crab as indicators. On the other hand, certain seedlings of Amelanchier spp., Malus floribunda, Crataegus crus-galli, and C. mollis did show marked foliage symptoms in the spring following August budding.

Tests were then set up to examine these species more critically. These experiments were conducted under field conditions. Every other seedling in a row was inoculated with buds from a tree known to be carrying the stem-pitting virus. Prior to inoculation a bud was taken from the seedling to be inoculated and placed into the adjacent plant, which served as the non-inoculated control and was encouraged to grow so as to provide propagation material if the inoculated test plant proved to be useful. The results of this test are listed in Table 1.

Table 1. Pomaceous hosts showing foliage symptoms following inoculation with the stem pitting virus.

Species	Number plants			
		Showing symptoms		
	Total	None	Mild	Severe
Crataegus mollis	31	27	3	1
C. crus-galli	36	26	8	2
Malus floribunda	5	2		3
M. platycarpa (clone B-39478)	12		12	
Amelanchier spp.	15	13		2

DISCUSSION

The data listed in Table 1 indicate that some seedlings of both Crataegus mollis and C. crus-galli show foliage symptoms following inoculation with buds infected with the stem-pitting virus. Typical foliar symptoms of stem pitting on Crataegus, shown in Figure 1, consist of a mottled foliage condition generally associated with a pronounced dwarfing of the plant. The

[1]Journal Series Paper No. 1925, approved by the Director of the Missouri Agricultural Experiment Station.

FIGURE 1. Typical symptoms of the stem pitting virus in Crataegus crus-galli. Inoculated clones on left, non-inoculated control on right.

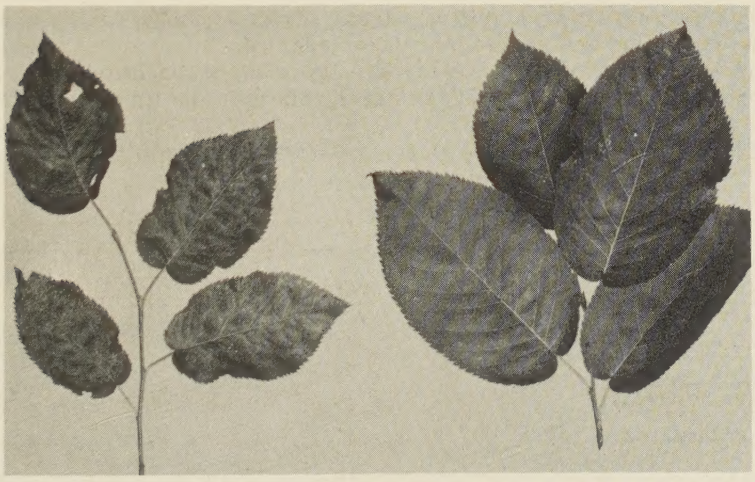

FIGURE 2. Symptoms of the stem pitting virus in Amelanchier spp. Leaves from inoculated plant on left, leaves from non-inoculated control plant on right.

symptoms expressed on Amelanchier following inoculation were essentially those described earlier[2]. Malus floribunda reacted to infection with a marked mottling of the leaves accompanied by a mild rugosity. Generally, the leaves on the inoculated plants were somewhat smaller than those on the control. M. platycarpa showed a mild mottling on the leaves. The single clone of M. platycarpa and all three clones of M. floribunda showed severe wood pitting in addition to the foliage symptoms.

SUMMARY

Certain clones of Malus floribunda, M. platycarpa, Crataegus mollis, C. crus-galli, and Amelanchier spp. showed marked foliage symptoms the season following inoculation with the stem pitting virus. These clones are being increased and may be useful as virus indicators for apple virus investigations.

MISSOURI AGRICULTURAL EXPERIMENT STATION
(Plant Disease Reporter Supplement 254. 1959)

[2]Millikan, D. F., and H. W. Guengerich. 1955. Transmission to Amelanchier of an agent causing a disorder in apple. Phytopathology 46: 130.

TOLERANCE OF SOME HARDY APPLE STOCKS TO THE STEM-PITTING VIRUS OF APPLE[1]

D. F. Millikan and H. W. Guengerich

Abstract

Experimental inoculations indicate that certain promising hardy body stock clones of apple show no symptoms characteristic of those produced by the stem-pitting virus. The rubbery wood indicator, Lord Lambourne, as well as other body stock clones, show severe pitting similar to that found on Virginia Crab.

INTRODUCTION

Incompatibility between scion varieties Grimes and Delicious, and Virginia Crab was noted as early as 1933 by Lantz (4). Later, Maney (2) reported that Stayman was highly incompatible with Virginia Crab. In 1954, Smith (5), Tukey et al. (6), and Miller (3) listed numerous incompatibilities between scion varieties and Virginia Crab. In 1956 this disorder was shown to be due to a transmissible virus (1). As observations by the authors and others (3, 5, 6) indicated widespread occurrence of this virus throughout North America in many commercial varieties, it seemed advisable to determine the relative tolerance of hardy apple stocks to infection with the stem-pitting virus.

EXPERIMENTAL METHODS AND RESULTS

Several commonly used or potential body stocks collected for increase were bench-grafted to domestic seedlings and lined out in nursery rows. The 1-year budlings were inoculated in August by budding with a source of inoculum known to cause severe pitting on Virginia Crab. Cutting back to the inoculating buds the following spring forced the inserted buds into growth. Observations were made 1 year after inoculation and in subsequent years. Readings were made

Table 1. Tolerance of several body stock clones to infection with the stem pitting virus.

Clones showing pitting	Clones showing no pitting
Delcon	K-14[c]
Spy 227	K-18
Lord Lambourne[b]	K-24
A-2 (Alnarp A-2)	Rescue[a]
K-29	M. kitaika PI 107219
Malus platycarpa (B-39478)	Columbia
M. kitaika PI 107200 (very mild after 3 yrs.)	Canada Baldwin[a]
	Antonovka (Ottawa strain)
M. kitaika PI 154157 (very mild after 3 yrs.)	Charlamoff
	Belle de Boskoop[b]
M. floribunda var. Paul's Scarlet	Besseminka
M. sikkimensis	Antonovka zhaltaia
M. sikkimensis seedlings	
Hibernal	

[a]One year's observations, only.
[b]Lord Lambourne -- indicator for rubbery wood. Belle de Boskoop -- indicator for rough skin.
[c]K clones - selections of French Crab from Kansas

[1]Journal Series Paper No. 1926, approved by the Director of the Missouri Agricultural Experiment Station.

by stripping the bark from the inoculated trees and comparing the presence or absence of pitting with the pitting found on the inoculated Virginia Crab controls. The results of this study are listed in Table 1.

DISCUSSION

Considerable variability was noted in the reactions of some commonly used and potential body stocks to infection with the stem-pitting virus. Such stocks as Spy 227 and M. sikkimensis were affected and showed pitting as severely as any Virginia Crab found in our surveys. Other stocks such as M. kitaika PI 107200, M. kitaika PI 154157, and K-29 showed only mild pitting after 3 years. M. kitaika PI 107219, K-14, K-18, K-24, Columbia, and Charlamoff showed no pitting 3 years after inoculation. Additional tolerance or resistance is suggested in the case of Rescue, Mount, Canada Baldwin, and a clone of Antonovka. These clones were free from pitting 1 year after inoculation.

SUMMARY

Several body stocks were evaluated for freedom from stem pitting following inoculation with the stem-pitting virus. Stocks K-14, K-18, K-24, M. kitaika PI 107219, Canada Baldwin, Antonovka (Ottawa strain), Antonovka zhaltaia, Besseminka, and Charlamoff showed no pitting in 1 to 3 years after inoculation. Stocks K-29, M. kitaika PI 107200, and M. kitaika PI 154157 showed mild pitting 3 years after inoculation.

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